Unit-II

**SOIL AND CLIMATIC CONDITIONS PREVALENT IN RAINFED AREAS**

Introduction: Soil and climate are two major factors that dictate the productivity of crops in Rainfed agriculture. Rainfed soils are generally of poor quality. These have very weak buffering and resilience capacity. The soils suffer from excess of salts (saline-alkali soils) in arid and semi-arid areas and acidic (acid soils) in sub-humid and humid areas. Micronutrients and ameliorants (mainly lime) are deficient and need supplementation periodically. The soils are mostly coarse textured, highly degraded with low water retentive capacity, multiple nutrient deficiencies, and thus are not conducive for intensive cropping.

**Characteristics of Dry land soils**

* Dry land soils are generally low in organic matter and alkaline to slightly acidic in reaction in the surface have CaCo3 accumulation in the upper 150 cm soil layer.
* Weak to moderate profile development, coarse to medium texture and having low biological activity.
* Nearly two-thirds of Indian’s land mass has more than 3% slope and is slightly undulating.
* The top soil shows many textural groups like loamy sand, sandy loam, loam, silt to clay loam.
* The soils are predominantly coarse textured and hence retain less water and nutrients.
* The crops grown on them are prone to drought and nutrient deficiencies. The low organic matter content is due to sparse vegetation producing little residues.
* The top soil when eroded, is devoid of organic matter, thus resulting in deficiencies of several nutrients.
* Removal of vegetation, intensive agriculture, uncontrolled and excessivegrazing, and large unprotected fields devoid of protective vegetation are known to cause wind erosion.

The inherent properties of dry land soils lead to degradative processes in Rainfed semi-arid tropics, impose the following constraints for successful crop production:

* Much reduced permeability,
* Poor or restricted root development,
* Tillage and seeding problems,
* Poor seedling establishment,
* Uneven soil wetting,
* Salinity and shallow water table and
* Poor soil fertility,
* Uneven topography with high erodibility,
* Low moisture storage and release capacity,
* High surface crusting that leads to poor crop stand establishment.

**CLIMATE OF RAINFED AREA**

Climate is one of the major factors influencing crop growth. Favorable weather is essential for good harvests. Weather abnormalities like cyclones, droughts, hailstorms, frost, high winds, extreme temperature and insufficient photosynthetic radiation etc., may generally lead to very low or even no yields. Hence, characterization of agro climates is a prerequisite to know the potential of a region, especially under dry land conditions for improving and stabilizing the productivity.

**Types of climate in different regions of India**

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| --- | --- |
| **Region** | **Climate type** |
| Saurashtra, Kutch. Western Rajasthan, Bellary (Karnatak), Anantapur (AP) & Tirunelveli (TN) | Arid |
| The area from Kanyakumari in the south to Punjab in the north, covering practically the whole of the Peninsula, east of western ghats and Gaya-Jumai area in Bihar. | Sem-arid |
| Northern parts of Punjab. Haryana, UP, Bihar,  WB, Orissa, MP, Vidarbhaand northern parts of AP and from Chennai to Nagapattanam (TN). | Sub-humid (moist or dry) |
| NE region, west coast and adjoining hills | Pre-humid & humid zones |

**SOIL AND WATER CONSERVATION TECHNIQUES**

**Soil conservation**

* Soil conservation is using and managing the land based on capability of land itself involving the application of the best management practices leading to profitable crop production without the land degradation.
* The basic principles behind the soil conservation measures is to minimize the velocity of surface runoff by transforming undulating topography in to relatively flat surfaces which increase the opportunity time for rain water to infiltrate in to the soil.

**Water conservation**

Water erosion occurs simultaneously in two steps:

* Detachment of soil particles by falling rain drops and transportation of detached particles by flowing water.

**Principles of water erosion**

* Maintenance of soil infiltration
* Soil protection from rainfall
* Control of surface runoff
* Safe disposal of surface runoff.

**Agronomic measures**

Agronomic measures for soil and water conservation helps in:

1. Intercept rain drops and reduce the splash effect,
2. Obtain a better intake of water by soil,
3. Reduce and retard the surface runoff and
4. Maintain in-situ moisture.

**Major control measures:**

1. **Summer ploughing:**

* Summer ploughing is defined as the ploughing the field across the slope during hot summer with the help of specialized tools with primary objective of opening of the soil crust accompanied by deep ploughing.
* Perform deep summer ploughing with pre-monsoon showers (during may) to recharge the soil profile. It facilitates to sow the crops immediately after onset of south west monsoon. It increases water content of soils and reduces runoff. It also reduces pest and diseases and weed infestation.

1. **Tillage:**

* Tillage alters the soil physical characters like porosity, bulk density, surface roughness and hardness of pans.
* It helps to control weeds, increase intake of water and reduction of soil loss by creating obstruction to surface flow of water.
* Rough and cloddy soil surface resists the force of wind from causingerosion.

1. **Choice of crops:**

* Row crops or tall growing crops such as sorghum, maize and bajra are not effective in conserving soil as they expose majority of soil and hence they are erosion permitting crops.
* Whereas close growing crops such as cowpea, groundnut, green gram which protects the soil are erosion resisting crops they are very effective in reducing soil loss by minimizing the impact of rain drops and acting as obstruction to runoff.

1. **Ridges and furrows:**

* Ridges and furrows thus formed act as continuous barrier to the free movement of water downwards thus provides more infiltration time. Hence, the removal of soil along with nutrients is checked to a greater extent leading to increment in soil fertility and crop yield.
* Ridges and furrows is one of the in situ soil and water conservation methods for black and red soils cause an increase of up to 15% in crop yields.
* Dead furrows, broad furrows, catch pits or scoops and inter row water harvesting are types of ridges and furrows.

1. **Contour farming:**

* A line joining the points of equal elevation is called contour. All the cultural practices such as ploughing, sowing and inter cultivation done across the slope to reduce soil and water loss. By ploughing and sowing across the slope each ridge of plough furrow and each row of crop act as obstruction to the runoff and provide more time for water to enter in to the soil leading to reduced soil and water loss.

1. **Ploughing across the slope:**

* The property of water is to flow down the slope. Greater the slope, more is the velocity of runoff and hence more is the energy of water to scour and carry the valuable and nutritive top soil. Similarly, longer the length of a sloppy and more is the velocity and hence energy of flow to carry soil particles. If the length of a slope is doubled, the energy increase varies with square of the increase of length. It results in two major losses to the farmers of this regions.
* Water gets less opportunity time to seep in to the s**oil.** So in situ moisture conservation is reduced, resulting in less cropping intensity is such the permeability of the hard rock soil less.
* Secondly, the top soil containing organic matter and applied nutrients gets eroded, thereby the farmer is at loss both in wasting money in puts and getting less production as compared to expectations.
* These problems can be solved if the length of run in the sloppy land is reduced and some obstruction is placed before the flow to increase its opportunity time to infiltrate in to the soil. This can be achieved by ploughing the sloppy land across the slope and have the corrugation termed due to subsequent ploughing as such without levelling sowing.

1. **Cover crops:**

* Erosion can be reduced if the surface is fully covered with foliage: blackgram, greengram and fodder grasses like *Cenchrus ciliaris, Cenchrus glaucus*, dinnanath grass
* Both contour and cover cropping can be practiced when the slope is less than 2%.

1. **Organic matter addition:**

* Incorporation of organic matter in soil brings about a marked improvement in physical, chemical and biological properties of soil besides addition of nutrients.
* It improves soil aggregates, infiltration capacity of soil, moisture holding capacity of soil and reduces evaporation losses from soil.

1. **Strip cropping:**

* This consists of growing erosion permitting crops and erosion resisting crops in alternate strips on contour with the objective of breaking long slopes to prevent soil loss and runoff. The erosion resisting and permitting crops ratio is 1:3.
* The erosions resisting crops are mostly legumes like groundnut, *Glycine max* which spread and cover the soil and do not allow runoff water to carry much soil with it the soil which flows from the strips growing erosion permitting crops is caught by the alternating springs. The erosion permitting crops are jowar, bajra and cotton.
* In selecting a suitable legume crop it should be seen that the maximum canopy and root development of the crop coincide with the period of high intensity of rainfall.

1. **Mulching:**

* A mulch is natural or artificially applied layer of plant residues or other material on the surface of the soil with the objective of moisture conservation, temperature control, prevention of surface compaction or crust formation, reduction of runoff and erosion, improvement in the soil structure and weed control.
* Artificial mulches of different kinds such as *Jower or bajra* stubles, paddy straw or husk, sawdust etc., increase absorption of water and minimize evaporation. They also control runoff and soil losses

1. **Rotation of crops:**

* Rotation means growing a set of crops in regular succession over the same field within a specified period of time. Continuous growing of jower or bajra crop causes more erosion, but if followed by a legume crop which covers the soil is causes less erosion.
* Rotation also helps in removal plant nutrients in a uniform way from future depth of soil and maintaining the fertility of the soil in dry farming region of Maharashtra adoption of gram, jowar rotation not only helps in conservation of moisture.

1. **Planting of grasses for stabilizing bundhs:**

* Grasses prevent soil erosion and improve soil structure. The entire soil mass is penetrated by countless roots and soil aggregates and particles by the root system. Grasses should be grown on bunds which are not suitable for cultivation, both for checking erosion and proving pasture for cattle. Rhodes and napier grass.

1. **Planting of trees and afforestation:**

* Forests conserve soil and water quite effectively. They not only obstruct the flow of water, but the falling leaves provides organic matter which increases the water holding capacity of the soil.
* If tree planting is done in the planned manner in open areas, it will serve as good wind break and if done along the banks of streams and rivers, it will regulate their flow. Farm forestry is another important aspect in soil and water conservation.

**SOIL AND WATER CONSERVATION METHODS – MECHANICALS PRACTICES**

**Mechanical control measures**

Mechanical measures constitute various engineering techniques and structures. They reduce the runoff and impound water for longer time to help infiltration in to the soil. Their construction and design will depend upon rainfall, soil slope and such other factors. These measures are costly but if properly maintained will improve the land over a long period of time. Bunding, terracing, gully or nala control and construction of tanks are mechanical measures requiring engineering techniques.

**Bunding:**

1. **Block bunding:** Bunding for control of soil erosion and conservation of surface runoff was known to farmers for centuries. These bunds are constructed of earth or stone or both, at a great cost, to impound water and arrest soil washed from the fields lying above. They are high and broad enough to withstand the force from the catchments. Water is let out at the end of the monsoon and land which has received fertile silt is sown with crops. Such type of big bunds is not constructed now as contour bunding has been taken up on catchment basis.
2. **Contour bunding:** The slope of land is broken up in to smaller, more level compartments by constructing earthen bunds of suitable size on contours. Each bunds thus hold rain water within each compartments. It has been estimated that about 75 million ha of land i.e., about one fourth of the common land surface suffering from soil erosion. The planning commission has therefore laid out great stress on contour bunding programme, because bunding alone has been found to increase crop yield by 20 to 30%.
3. **Contour tillage:** On hilly land all tillage operations and the sowing of crops should be done at right angles to the slope of land. On long slopes, the field may be laid out in narrow strips across the slope.
4. **Gully or nala control:** Gully or nala control is very essential to prevents its extension and further destruction of cultivated lands and grass lands. In first step, water flowing in to gully should diverted away by means of a bund. The second step is to build several obstructions in gully such as rock dams. After that, the slopping sides are planted with grass and trees.
5. **Terracing:** cultivated lands having land slopes above 10% particularly in hilly areas should be put under bench terracing. On steeper slopes terraces or flat platforms are constructed in steps like series across the slopes. It is like a level benches for retaining and distributing rainfall for controlling run off. Bench terracing is very effective in reducing soil erosion in hilly areas.

**DROUGHT: DIFFERENT TYPES OF DROUGHTS, EFFECT OF WATER DEFICIT ON PHYSIOMORPHOLOGICAL CHARACTERISTICS OF THE PLANTS, CROP ADAPTATION AND MITIGATION TO DROUGHT**

**Introduction**

* Low rainfall or failure of monsoon is a recurring feature in India. This has been responsible for droughts and famine.
* The word drought generally denotes scarcity of water in a region. Though, aridity and drought are due to insufficient water, aridity is a permanent climatic feature and is the culmination of a number of long term process.
* However, drought is a temporary condition that occurs for a short period due to deficient precipitation for vegetation, river flow, water supply and human consumption. Drought is due to abnormally in atmospheric circulation.

**Definition of drought:**

* Early workers defined drought as prolonged period without rainfall.
* The irrigation commission of India defines drought as a situation occurring in any area where the annual rainfall is less than 75% of normal rainfall.

**Classification of drought:**

Droughts can be classified based on source of water availability and time of occurrence in to three categories:

1. **On the basis of source of water availability**
2. **Meteorological drought**

The meteorological droughts mainly indicate deficit rain of different quantum. The IMD classified this drought as follows from the rainfall departure.

1. **Slight drought:** When rainfall is 11 to 25% from the normal rainfall.
2. **Moderate drought:** When the rainfall is 26 to 50% less than the normal rainfall
3. **Severe drought:** When rainfall is more than 50% less than the normal rainfall.
4. **Hydrological drought:** It is defined as the situation of deficit rainfall when the hydrological sources like streams, rivers, lakes, wells dry up and ground water level depletes. This affects industry and power generation.
5. **Agricultural drought:** This is the situation resulted from inadequate rainfall, when soil moisture falls too short to meet the water demands of the crop during growth. Thus affects the crop may wilt due to soil moisture stress resulting in to reduction of yield.
6. **On the basis of time of occurrence:** Drought differs in time and period of their occurrence and on this basis Thormathwite delineated following three areas;
7. **Permanent drought area:** this is the area generally of permanent dry, arid particularly desert regions. Crop production due to inadequate rainfall is not possible without irrigation. In this areas vegetation like cactus, thorny shrubs, xerophytes etc., are generally observed.
8. **Seasonal drought:**  It occurs in the regions with clearly defined as rainy (wet) and dry climates. Seasonal drought may occur due to large scale seasonal circulation. This happens in monsoon areas.
9. **Contingent drought:** This results due to irregular and variability in rainfall, especially in humid and sub-humid regions. The occurrence of such droughts may coincide with the grand growth periods of the crops when the water needs are critical and greatest resulting in to severity of the effects i.e. yield reductions
10. On the basis of medium: On the basis of medium in which drought occurs. Mexico (1929) has divided the drought in to two types.
11. Soil drought: It is the condition when soil moisture depletes and falls short to meet potential evapotranspiration of the crop.
12. Atmospheric drought: This results from low humidity, dry and hot winds and causes desiccation of plants. This may occur even when the rainfall and moisture supply is adequate. Strategy to mitigate drought or how to overcome the drought:
13. Preventing and recycling of excess runoff.
14. Deep tillage to absorb and hold maximum moisture.
15. Timely weed management to control water loss by ET.
16. Planning for suitable cropping system.
17. Selection of short duration and drought resistant crops
18. Contingency crop planning for abnormal weather situation.
19. Management of various inputs to suit the climate.
20. Conserving the soil moisture by agronomic practices like mulching use of antitranspirant on the crops to reduce ET.
21. To apply irrigation.
22. Reduction of plant population to reduce ET.
23. Timing of foliage to reduce ET.

**Drought year:** the year is considered ‘drought year’, when less than 75% rainfall is received.

**MITIGATION OF DROUGHT**

Drought is recurring phenomena and its occurrence cannot be avoided. However, its impact can be minimized through application of science and technology in developing suitable drought managements plans. Generally, there are always some areas, which are not affected by drought while some areas may be reeling under drought. Therefore, there is a need to develop infrastructure for mitigation of drought. Mitigation action specific to drought can be defined as short and long term action programmes or policies implemented in advance of drought that reduced the degree of risk to people, property and increases productive capacity.

**Drought mitigation strategies**

Some of the measures, which would help in effective response and mitigate hardship of the people are as follows:

* Arrangement for responsible buffer stock of food grain and fodder.
* Ensure supply of good drinking water in rural areas for human and livestock in drought affected areas.
* Assess fodder requirements in drought affected districts and locate areas where shortages are likely to occur and arrange supplies from outsides.
* Fodder cultivation to be encouraged wherever feasible.
* Rejuvenation of traditional rain water systems viz., Nadis, Tankas, Khadnis etc. Rain water harvesting for both drinking and cropping.
* Management of human livestock population to reduce pressure on fragile arid ecosystem.
* Timely availability of credit, postponement of revenue collection and repayment of short-term agricultural loans.
* Appropriate land use planning (inter cropping system), discouraging water intensive crop, and encouraging sprinkler and drip irrigation systems.
* Creation of local task force in each district to initiate relieve measures immediately after the drought takes place.
* Implementation of crop and livestock insurance schemes.
* Provision for cattle camp in drought affected areas.
* Early warning and drought monitoring should be carried out on the basis of long, medium and short-term forecast.

**CROP ADAPTATION TO DROUGHT**

It is the ability of a plant to maintain favorable water balance and turgidity even exposed to drought conditions there by avoiding stress and its consequences.

1. **The mechanism for conserving water:** -
2. **Stomatal mechanism:** Stomatal of different species vary widely in their normal behavior and range. In some species stomata remain open continuously or remain closed continuously. Many cereals open their stomata only during a short time in the early morning and remain closed during rest of the day. However, mechanism of conserving water based on the closure of stomata will inevitable load to reduce photosynthesis and may lead to drought induced starvation injury.
3. **Increased / photosynthesis efficiency:** On possibility for overcoming limitations on photosynthesis, imposed bicoastal closure as means for increasing resistance to loss of water by transpiration there by accumulations of CO2 would be at higher rate for a given stomatal opening (Hatch & Stack, 1970). A number of imperfect crop plants (maize, sugarcane, sorghum, fox tail & finger millets) as well as certain forage species Bermuda grass, Sudan grass and Rhodes grass fixed most of CO2 in to the C4 of malic and aspartic acids so called C4 dicarboxylic acid (C4) pathway.
4. **Low rate of cuticular transpiration:** The typical example is the cactus. Thick cuticle results in low rate of transpiration.
5. Decreasing transpiration by a deposit of lipids layers on the surface of leaves on exposure to moderate drought e.g. soybean.
6. **Reduced leaf area:** The principle means of reducing water loss of xenomorphic plants is their ability to reduce their transpiring surface. The rolling of leaves has shown to reduce transpiration by almost 55% in semi-arid conditions and by 75% in desert xerophytes.
7. **Leaf surface:** Various morphological characteristics of leaves reduce the transpiration rate and may affect survival of plants under drought conditions. Leaves of with thick cuticle, waxy surface and the presence of spines etc., are common and effective.
8. Stomatal frequency and location: A smaller number of stomata retard the development of water deficits. In certain species, the stomata are located in depression or cavity in the leaves which is feature can further reduce transpiration by limiting the impingement of currents.
9. Effect of awns: A awn varieties of wheat predetermine in the drier at warmer regions and have been found to yield better than aweless one especially under drought conditions though there are exceptions (Gurandhacher, 1963). Awns have chloroplasts stomata and so as photosynthesized. It has been found that the contribution of the way to the total dry weight matter of kernels was 12% of that the entire plant.